The Sidereal Messenger.

CONDUCTED BY WM. W. PAYNE,

Director of Carleton College Observatory.

MAY, 1886.

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By faith we understand that the worlds have been framed by the word of God, so that which is seen hath not been made out of things which do appear.

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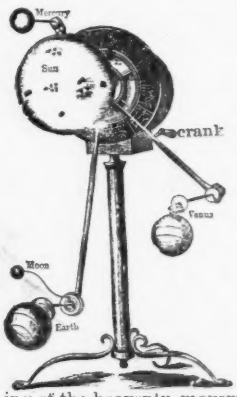

HELIOTELLUS

When the Earth's axis is pointed to the north, it will continue so pointing throughout the revolution, and will be in the Ecliptic. The Earth rolls over from west to east, and if the Equator be continued to the sky, it will meet the Equinoctial. So with the Ecliptic, if continued, it will come near to the Moon, near to Mercury, near to Venus, and always to the Sun.

I have now in my possession all the Heliotelluses for sale, made with a set of tools costing $25,000, which tools were afterwards destroyed by fire. They were so accurately made that the Heliotullus cannot now be duplicated for less than $250 each. The greatest impediment I find in their introduction is the Tellurian, which makes a false showing of the heavenly movements. It is a device in which the Earth's axis wabbles around the zenith and never points to the north. This is the greatest bearier to the comprehension of this most sublime of the sciences. The Heliotellus shows so near the truth that it is not hard to comprehend.

In high schools, seminaries, colleges, and all places of learning we find many globes and maps of the earth, but where can one be found having the Equator of the Earth so constructed that if continued it will meet the Equinoctial in the right place on the sky? Every child should have a truthful understanding of science. The Ecliptic should be correctly understood. All instruments which show imperfect teaching are hurtful; those which teach correctly are useful. The one should be rejected, the other sought for, and when found, should be prized even as a "pearl of great price." Three hundred such I now possess, all perfectly made, and I now propose to sell two hundred at the reduced price of $20 each, or for $65, the price of one, I will send four, each well packed in a strong box to carry by express anywhere.

Address, HENRY WHITALL,
1019 N. 3d St. Camden, N. J.

XUM

The Sidereal Messenger

CONDUCTED BY WM. W. PAYNE,

Director of Carleton College Observatory, Northfield, Minnesota.

"In the present small treatise I set forth some matters of interest to all observers of natural phenomena to look at and consider."—GALILEO, *Sidereus Nuncius*, 1610.

VOL. 5. No. 5. MAY, 1886. WHOLE No. 45.

THE ORIGIN OF THE RED GLOWS.*

REV. SERENO BISHOP, HONOLULU, HAWAIIAN ISLANDS.

These brilliant phenomena first began to be observed on the 28th day of August, 1883. They have continued with varying but diminishing intensity for more than two years. They first appeared in great splendor along an equatorial belt of 18,000 miles or more. They gradually extended with reduced brilliancy to the Temperate zones, exciting the wonder of Europe and the United States in November, 1883.

The most conspicuous of these phenomena take place during one hour or more before sunrise and after sunset. They may be considered as a great intensifying and prolongation of common twilight sky reflections, in consequence of a recent introduction into the higher regions of the atmosphere of some kind of finely divided matter which powerfully reflects the *Sun's* rays, especially the red. The usual order of changes is as follows:

Clouds not obscuring the view, the horizon where the *Sun* has just set is occupied by a bright silvery luster. Above this, to a height of 30° or 40° a yellowish haze fills the western sky. Although seemingly opaque and dense, the presence in it of *Venus* or the crescent *Moon* shows it to be entirely transparent.

* The essay winning the third prize in the series of the Warner Red Light Prize Essays, the committee of award being Prof. Daniel Kirkwoood, Bloomington, Indiana; Prof. M. W. Harrington, Ann Arbor, Michigan, and Prof. Ormond Stone, University of Virginia, Virginia.

This haze rapidly changes in color and extent, ranging through greenish yellow and olive to orange and deep scarlet. As the dusk advances, orange and olive tints flush out on all sides of the sky, especially in the east. The chief body of color gathers and deepens over the sunset, rapidly developing the red. In from twenty to thirty minutes after sunset, deep scarlet has overpowered all other hues, flaming along 60° of horizon, and 10° of altitude. This rapidly sinks and intensifies. There is a dark interval above the red. The stars begin to appear. While yet the color flames low, above the dark space appears a repetition of the orange and olive hues. Seen against the night-sky, these secondary reflections or after-glows are seemingly more brilliant than the primary ones. Again the colors change and deepen into red, and after the stars are all out, and the earlier flame has sunk below the horizon, and far later than any common twilight, a vast blood-red sheet covers the west. It has been seen rising as high as 20°. As it sinks and rests low on the horizon, in the dark night sky, it precisely simulates the appearance of a remote and immense conflagration, for which it has in many places been mistaken. I have known our usual thirty minutes of twilight to be prolonged to ninety, before the last glow disappeared.

In the dawn recur the same appearances, but in inverse order. In September, 1883, they were singularly impressive and even terrific, as the first low sullen incandescence rose and spread and glared among the stars, as if the very heavens were in conflagration. Then, as well as at nightfall, a marked division occurs between the night-glow and that nearest to the *Sun*. During the earlier weeks of the display, the dark interval was often extremely distinct. One observer (*a*) described it as a "black bow." Another saw the shadow of the remote horizon sharply projected upon the under surface of the haze-canopy, but with fine serrations, probably the shadows of platoons of cumuli (*b*). Evidently at that early date the canopy of floating haze had a well-defined under-surface.

a Nature, vol. 29, p. 549. *b* Nature, 29, 549.

From the beginning, the upper limit of the night-glow has always been indefinite, since its light was reflected to it from the broad surface of the first glow, while the latter showed a clean shadow of the horizon from the *Sun* itself. In general it may be said that the tropical displays of these glows at their birth during the first week in September, as far surpassed the mild Glows seen world wide in November, as the plunging surges of a tempest surpass the tripping crests of a breeze. The entire dome of sky, above and around, seemed to heave with billows of lurid light, as the portentous masses of color poured out of the pellucid blue, while the west outflamed in broad conflagrations.

In September, during the day, as well as after sunset, many portions of the haze-canopy were noticeable as having a wavy or rippled structure (*c*). A conspicuous object when the *Sun* is high has been from the first, the opalescent silvery glow around the *Sun*. This occupies a circle of 25° radius or more. The outer part develops a pinkish hue, which against the blue sky shows lilac or chocolate tints. These have a singular effect when seen through rifts of cloud, as Capt. PENHALLOW (*d*) saw them on September 18, 1,000 miles N. E. of Honolulu. This sun-glow has been particularly discussed by M. A. CORNU in the *Comptes Rendus*, of September 23, 1884. He remarks peculiar modifications therein of the atmospheric polarization of the *Sun's* rays. Prof. F. A. FOREL has repeatedly discussed this sun-glow, which he has named (*e*) the "Cercle de Bishop," after the first observer of the phenomenon at Honolulu. Prof. HUGGINS found this sun-glow putting an end to his previously successful photography of the solar corona.

The height of the main body of this haze in the atmosphere has been variously estimated at from fifteen to forty miles. The present writer, as the result of much and early observation, has no doubt that in the early part of September, 1883, no part of its under surface was less than thirty or forty miles above

c Nature, 29, 174. *d* Nature, 29, 174. *e* Archives des Sciences Physiques et Naturelles, tome 13, p. 465.

the ground. All estimates should be based upon the first reflections and not upon the secondary glows. No decisive tests of the nature of this reflecting matter have been secured. The spectroscope has distinctly indicated the presence of large quantities of aqueous vapor (*f*), accompanied by other peculiar influences. Fresh fallen rain and snow have repeatedly yielded a dust of microscopic particles possessing the same constitution as the fine ash-fall from Krakatoa.

The most generally accepted theory of the source of this new matter in the sky, attributes it to the great eruption of the crater of Krakatoa or Krakatao in the Straits of Sunda on the 27th of August, 1883, one day before the first definite record of red glows, which were seen on the 28th, at both Mauritius and the Seychelles, 3,500 miles west of Krakatoa. Before considering the evidences in support of this theory, notice needs to be taken of two other hypotheses, which have been advocated.

One of these assumes the meeting of our globe with some cosmic cloud of impalpable dust, which was arrested in the upper strata of the atmosphere.

The other hypothesis supposes the cosmic cloud to have been composed of hydrogen, which united with the oxygen of the atmosphere to form the aqueous vapor evidently constituting so considerable a part of this haze.

The latter hypothesis seems open to the objection that such uniting of the two gases is usually attended with active combustion, none of which was observed.

Both hypotheses suffer from the total absence of evidence that any such cosmic cloud did approach the earth on or before August 28, or since that time. The matter actually introduced into our atmosphere is brilliantly conspicuous in the sunlight. Yet we are asked to believe that a vast nebula of such matter approached unseen and enveloped the *Earth*. In 1861, the tail of an immense and brilliant comet actually swept the *Earth*. Yet so tenuous was the impinging matter that no traces of its

f C. Michie Smith, Nature, 29, p. 28.

presence were left behind. A cloud sufficiently dense to create the present haze, must, in its approach, have presented the aspect of a most compact and refulgent body. So far from being possibly unobserved, it must have terrified mankind.

Another and most serious objection lies in the original narrow localization of this haze in an equatorial belt. It is difficult to conceive of a cosmic cloud, possessing a mass adequate to the immense effects produced, which should not occupy such dimensions as to completely envelop the globe at once, producing glows simultaneously all over the *Earth*, not to consider the improbability that the course of such a dense little nebula after collision should precisely coincide with the Equator. It must be remembered that stray cometary or nebulous matter (not solid meteors) afloat in cosmic space, since it possesses small mass and feeble centripetal force, necessarily assumes immense volume and extreme attenuation, compared with which this haze is solidity itself. The entire quantity of this peculiar matter actually diffused in our atmosphere, must originally have been equivalent to many cubic miles of solid matter, which represents a volume of cometary material immensely exceeding the dimensions of the largest planet. The actual localization of the first glows in the Tropics thus precludes reference to cosmic sources, and compels us to seek a terrestial one.

Many have felt that the long protacted continuance of this haze in the air necessitates the supposition of renewed supplies from fresh sources, as if perhaps the *Earth* were continuing to traverse successive regions of cosmic vapors (which no one has seen). Had there been but one original introduction of the haze, must it not long since have been precipitated and disappeared? But we have to consider how slow is the subsidence of even coarse common dust, especially in currents of air. The haze matter in question has probably forty miles to fall. If only twenty miles, or 105,600 feet, it must fall one hundred and forty-four feet in a day to reach the ground in two years. It seems improbable that these ultra-microscopic particles could

descend at one-tenth of such a velocity (*g*). It seems likely, on the contrary, that the finer particles of this matter will continue suspended and produce their glows for many years to come.

Leaving these nebulous imaginings, let us pursue the plain, if humble, historical method of inquiry. When and where were these phenomena first observed? Under what peculiar conditions and with what attendant circumstances did they appear? In what successions of time and place did they first occur, and to what actual point of origin on the *Earth's* surface may they be traced?

Pursuing this indispensable method of physical investigation, we find that the earlier appearances of the sunset glows, were as a rule immediately preceded by a peculiar veiling and discoloration of the *Sun's* disc, commonly termed the "Green Sun." While the sky was cloudless, or faintly obscured by undefinable haze, the disc of the *Sun* was described (*h*) as pallid, livid, bluish, coppery, greenish, "bird's-egg hue," "plague-stricken." It could be directly viewed with the naked eye, and its spot distinguished. At the altitude of 40° the *Sun* generally resumed its ordinary aspect, but again turned pallid and green as it descended in the west. In some cases the sunset glares immediately succeeded, while in others they were not reported, the haze probably having been too dense for the *Sun's* rays to penetrate it obliquely, so as to be reflected from its under surface. The first appearances of the red glows were so intimately associated with the green suns that it is impossible not to treat them as different aspects of one and the same phenomenon.

It seems in place here to cite Mr. WHYMPER's observation (*i*) of green sun and wonderful sky-glows combined. On the 3d of July, 1880, on the upper slopes of Chimborazo, Mr. WHYMPER witnessed an eruption of Cotapaxi, smoke from which drifted over the observer's position. Seen through it, the *Sun's*

g John Le Conte, Nature, 29, p. 404. *h* Nature, 28, pp. 576, 577 — Vol. 29, pp. 28, 6, 133, 181, 549. *i* Nature, 29, p. 199.

disc assumed a peculiar green, while the changing colors of the sky "surpassed in vivid intensity the wildest effects of the most gorgeous sunsets."

From such records as were accessible, I have constructed the accompanying tabulated statement of the earlier recorded appearances of the green suns and the red glows. The latitude and longitude of each locality are given in the table, with the date of the first appearance of the phenomenon at each point. The distance from Krakatoa is estimated in English miles, the number of hours in transit and the velocity of the current calculated. The source of information is specified for each of the seventeen different localities, three of which were on vessels at sea in the Pacific. To these, Maranham might be added. I lack the needed reference. At six of these localities, both the green sun and the red glows were reported as having been seen on the same day. At four points only red glows were reported, and at seven only green suns.

The most remarkable fact evidenced by this table is that the earliest appearances of these phenomena are thereby traced along a line of points, successive from east to west, lying very near the Equator, beginning at the Seychelles Islands in the Indian Ocean, and running thence, in successive days, through Cape Coast Castle, Trinidad, Panama, and Fanning's Island, arriving at Strong's Island on September 7, having traversed a great circle for 17,600 miles in about two hundred and thirty hours.

It thus appears that the original haze cloud, which first produced the red glows, swept west from the Indian Ocean in an equatorial stream or belt, which traversed more than two-thirds of the circumference of the globe at an average velocity of nearly eighty miles an hour. A precise estimate of its velocity between successive points is prevented by the imperfection of the observations made. The date at Cape Coast Castle is uncertain by one day. The dates at Seychelles and Mauritius are probably vitiated by the copious diffusion of volcanic smoke

LOCALITY.	LATITUDE.	LONG.	DATE.	DISTANCE.	HOURS.	VELOCITY.	GREEN SUN.	RED GLOW.	REFERENCE.
Krakatoa.....	6° 10′ S.	105° 30′ E.	August 27th A. M.						
Mauritius.....	20 20 S.	57 40 E.	" 28th, P. M.	3,600	30	120		R. S.	Nature, Vol. 30, p. 279
Seychelles.....	4 30 S.	55 20 E.	" 28th, P. M.	3,480	30	116	G. S	R. S.	" " 30, 280
Cape Coast Castle	5 25 N.	1 15 W.	Sept. 1st, A. M.	7,420	90	82	G. S.		" " 29, 133
Trinidad.....	10 30 N.	61 26 W.	" 2d, A. M.	11,600	127	91	G. S.	R. S.	" " 28, 577
Barinas, Ven.....	7 44 N.	70 22 W.	" 2d, A. M.	12,220	128	96	G. S.		" " 29, 76
Panama.....	9 .. N.	79 35 W	" 2d, A. M.	12,860	128	100	G. S.		" " 29, 152
C. S. Hurlburt....	17 .. N.	125 .. W.	" 3d, P. M.	16,000	201	80		R. S.	" " 29, 549
Fanning's Island..	2 40 N.	159 .. W.	" 4th, P. M.	18,400	218	84	G. S.		" " 29, 549
Jennie Walker....	8 20 N.	155 25 W.	" 4th, P. M.	18,200	218	84	G. S.	R. S.	" " 29, 549
Zelandia.....	5 .. N,	163 .. W.	" 5th, A. M.	18,800	230	82	G. S.		" " 29, 181
Maalaea.....	20 49 N.	156 28 W.	" 5th, A. M.	18,300	229	80		R. S.	" " 29, 573
Honolulu.....	22 17 N.	157 52 W.	" 5th, P. M.	18,400	241	79	G. S.	R. S.	" " 29, 174
Strong's Island...	5 .. N.	162 .. E.	" 7th, (6) P.M.	21,100	256	83	G. S.		" " 30, 537
New Ireland.....	5 .. S.	152 .. E.	" 1st, P. M.	3,200	107	30		R. S.	" " 29, 259
Madras.....	13 13 N.	80 12 E.	" 10th, A. M.	1,900	332	6	G. S.	R. S.	" " 29, 28
Ongole.....	15 32 N.	80 8 E.	" 10th, P. M.	1,900	342	6	G. S.	R. S.	" " 28, 576
Soudan.....	15 .. N.	32 .. E.	" 24th.	5,100	672	8	G. S.		" " 29, 181

prior to the regular movement of the upper stream. It seems quite clear, however, that an average velocity of about ninety miles an hour during the first half of the course of this haze-stream became reduced to about sixty miles in its later stages. These data appear to favor the conclusion of Mr. S. E. BISHOP, (*j*) that a stream of vapors was discharged over and upon the upper surface of the atmosphere of the Indian Ocean, by a powerful *initial* impulse, which drove it straight in a great circle, independently of atmospheric currents, and that this stream gradually suffered retardation as it descended into the atmosphere, finally ceasing over the Caroline Islands.

Without necessarily accepting this writer's theory, showing how such an impulse would be generated by the rotation of the *Earth*, it seems clear at least, that the inception of the equatorial haze-stream, and its attendant glows has been traced with positive certainty as far as the western side of the Indian Ocean and back to the 28th day of August. Eastward of this, our search is arrested by a vast pall of volcanic smoke proceeding from the greatest eruption described in history. But if we stretch our line back through this obstructing veil, thirty hours in time and 3,500 miles in distance, we find ourselves confronted by the great final explosions of Krakatoa on the morning of August 27th. Projected aloft from this crater by a succcssion of colossal explosions, a vast dome or cone of volcanic smoke on that day covered a region of not less than four hundred miles in diameter with absolute darkness for many hours, and spread a deep gloom for not less than 1,000 miles in every direction. From the summit of this immense reservor of vapors piled to an unknown height, the great equatorial haze-stream, appears to have issued, and sped westward around the globe. We have unquestionably traced it to its source in the vapor-mass that overhung the Indian Ocean less poetic than a cosmic nebula, but possessing reality, and with it have found the one sole and indisputable origin of the red glows which attended its course.

j Hawaiian Monthly, April 1884.

This does not imply that the swift equatorial smoke-stream embodied the whole of the glow-producing medium. It seems more probable that the larger portion of the vapors which became slowly and irregularly diffused over the globe during the ensuing seventy days, were drifted from the broad vapor-mass after the special stream had ceased. Thus we find the Indian peninsula untouched by the narrow stream which must have passed south of the Equator. But fourteen days afterwards, the haze arrived in full force and produced the geeen suns and red glows throughout Ceylon and Southern India, shortly afterwards appearing in Aden and the Soudan. We also find the glows at New Ireland, 3,200 miles due east from Krakatoa, in four days after the last explosions. In all these cases the transportation was comparatively slow, and probably due to atmospheric currents.

We need to consider the adequacy of the eruption of Krakatoa to have produced atmospheric effects of such magnitude and extent, not only "*belting* the globe with flaming skies," as in September, but by November enveloping the entire sphere in these fiery glares. Can Krakatoa be shown to have probably ejected a *quantity* of tenuous matter sufficient for this result? And can it be believed to have delivered such matter at such a *height* that in its descent it would form a haze canopy from thirty to forty miles above the surface?

We have absolutely and precisely traced the glows to their source, and so have the right to affirm that Krakatoa proved its colossal capacity to emit these vapors in such quantity and to such a height, by having actually done so. It is the objector's part to prove that it could not have done so, and did not. But waiving this advantage, we cite a preliminary official report on the nature and effects of the eruption of Krakatoa, made by Mr. R. D. M. VERBEEK (*k*). He makes an estimate of the quantity of those solid ejecta of the crater, which were so coarse as to be speedily precipitated. This amounted to eigh-

k Nature, vol. 30, pp. 10-14.

teen cubic kilometers or four and a half cubic miles, two-thirds of which fell as ashes and pumice within a radius of nine miles. He believes that at least an equal mass was delivered at the highest part of the column in the form of vapors and impalpable dust. It would be easy to present considerations to show that this finer portion must have vastly exceeded the coarser. But this might be speculative. We know that four and a half cubic miles of solid matter would overlay the entire atmosphere of the globe with a solid film of one seven-hundredth of an inch in thickness. This would doubtless be equivalent to many miles in thickness of such tenuous vapor and dust as have been floating in the upper ether.

As to the height of the column of ejecta emitted from Krakatoa at its highest activity, some estimate may be formed from known facts. The heaviest throes were very precisely determined (*l*) to have occurred at 9:55 and 10:45 A. M. on August 27. The latter one was immediately followed by a continuous down pour of mud and ashes upon the ship Charles Bal, then thirty miles distant (*m*). Seventy miles away, trees were extensively shattered by the weight of wet ashes (*n*). Batavia, one hundred miles away, was covered three inches deep with white ashes during the hours of total darkness following the greatest eruption. It seems impossible to find room for these facts on any estimate of the height of the eruptive column, as less than one hundred miles. It is true that *light* ashes might have great lateral diffusion from a column of far less height, but mud and wet ashes must have plunged quite directly downwards, so that a lateral throw of thirty to seventy miles must involve a vertical ascent of not less than one hundred.

The height supposed would have driven the eruptive column entirely through the atmosphere, and far above it, so as to deliver its contents over the surface of the atmosphere, to settle slowly down through its upper strata.

That the great column did actually thus lift and rend asunder the mighty mass of the atmosphere above the crater is made

l Nature, 30, 12. *m* Nature, 29, 140. *n* Leisure Hour, July, 1885, page 487.

probable by the unique oscillations of the barometers. A series of atmospheric waves was sped three times around the globe at the rate of seven hundred miles an hour (*o*). The length of each undulation was one million meters, that of the lowest audible sound waves being twenty-four meters. Twenty miles away from the crater the mercury rapidly oscillated between the 28th and 30th inches. It is thus evident that in the vicinity of Krakatoa the upper layers of the atmosphere were swinging up and down through a vertical distance of from ten to twenty miles every fifteen minutes. What could have done this less than an explosion driving clear through its entire depth?

As general evidences of the ultra-colossal character of the Krakatoa explosion may be adduced the following: 1. The waves driven upon the coasts of Anjer and Merak, thirty miles away, were found to have exceeded thirty-five meters or one hundred and twelve feet in height (*p*). Over the entire Anjer plain, fifteen miles by five, the inundation had uprooted every tree, and coral blocks of from twenty to fifty tons in weight had been torn from the bed of the sea and borne inland two or three miles (*q*).

2. The detonations of the eruption were heard throughout a circle whose radius is 1,800 geographical miles (*r*) equal to one-fifteenth of the surface of the *Earth*. Yet the heaviest could not be heard within a radius of forty miles from the crater. The sounds must have proceeded from tremendous rendings of the air at an immense height, whence the sounds were easily spread to vast distances, while from localities beneath, the massive torrents of descending ejecta cut off the sounds like a wall.

3. Ashes fell (*s*) at Singapore, 335 miles; at Buncalis, 915 N. W.; at Keeling, 1,200 miles S. W.; on the Australian coast, 1,050 miles E. S. E.; on the Arabella, 970 miles W. N. west. The entire area of ash-fall was officially estimated as at least

o Nature, 29, p. 181. *p* Nature, 30, 14—Leisure Hour, Sept. 1885, p. 636. *q* Leisure Hour, August, 1885, p. 556. *r* Nature, 30, 10. *s* Nature 40, 13.

750,000 kilometers (*t*), or as large as the Southern States east of the Mississippi.

The history of the eruption shows that upon the collapse of the mountain, on the morning of the 27th, the eruptions became submarine (*u*); the ocean waters rushed into the burning depths. Under the pressure of many miles of water the lava and the waters commigled and struggled with geyser-like discharges of augmenting violence, until finally there arose a continuous column of white-hot water and lava. Through the wide throat, apparently three miles in diameter, the vast column drove upwards, expanding and exploding as it flew into steam and pumice, till reaching one hundred miles or more in height, its mingled solids and liquids had exploded in the vacuum into thinnest ether.

The ashy ejecta, as analyzed, were mainly of glass in the form of pumice, together with the solid constituents of sea-water (*v*). This vitreous matter, being comminated by the force of the explosions to dust of ultra-microscopic fineness, formed together with the vaporized sea-water, a vast bulk of extreme tenuity and lightness above the atmosphere. Falling thence upon the upper strata of the atmosphere, and precipitating its coarser dust, its finer portions have continued suspended for more than two years in their ethereal encampment, and there are likely to abide for many years to come.

From the beginning the white sun-glow has been very uniform, while the night-glows have been quite irregular, although it is believed they have always been perceptible. In the northern tropics there has been a marked increase of brilliancy and continuity during each of the two winters. Probably the haze is distributed through the atmosphere in unequal and irregular drifts.

JOHN AITKEN'S demonstrations of the necessity of dust nuclei to the formation of ice spicules in the atmosphere (*w*) indicate that such ice-particles probably play a prominent part in the glows. Not improbably they would be in larger quantity

t Nature 40, p. 13. *u* Nature 30, p. 12. *v* Nature, 30, p. 13. *w* Nature, 29, p. 463.

in the Tropics during the winter, and so the glows increase at that season. Varying atmospheric conditions would also at all seasons vary the amount of congelation.

In conclusion the writer takes the opportunity to venture the surmise that a thorough study of the Krakatoa smoke-belt of September, 1883, and of its dynamic conditions, may furnish material aid in elucidating the still mysterious problem of the Belts of the planet *Jupiter*.

THE COMETS FABRY AND BARNARD.

WM. W. PAYNE.

It is a noticeable incident in the history of comets that two should happen to be in the same part of the heavens, and appear somewhat alike, as was true of comets Fabry and Barnard last month, especially since observers then knew that these comets could not possibly belong to the same cometary family. During the months of April and May these visitors are at their best, and hence a brief review of their study to the present time may be both timely and profitable.

Comet Fabry was discovered in Paris by M. FABRY on Dec. 1, 1885, and was immediately announced by telegraph as a faint object. On the evening of Dec. 2 it was seen by E. E. BARNARD, Nashville, Tennessee, who speaks of it as moderately bright. He saw a small star shining through it when the telescope was first turned upon it, but this was soon left behind by the rapid motion of the comet.

The elements of the orbit of this comet were computed by CHANDLER and WENDELL, H. OPPENHEIM, S. OPPENHEIM, WEISS, SCHULHOF and others. Those computed by H. OPPENHEIM are as follows:

$$\left.\begin{aligned} \omega &= 126^\circ\ 50'\ 27.''6 \\ \Omega &= 36\ 19\ 54.\ 0 \\ i &= 82\ 11\ 15.\ 0 \end{aligned}\right\} 1886.0$$

$T = 1886$ April 5.5398, Berlin M. T.

$\log.\ q = 9.804021.$

Mr. S. J. CORRIGAN, Nautical Office, Washington, calls atten-

tion to some points of special interest pertaining to this comet, viz: that its orbit resembles that of Comet 1790, III, that the plane of its orbit is so nearly perpendicular to the plane of the ecliptic, and the line of sight from the *Earth* that the determination of some elements of its orbit would be favorably certain, but that those of inclination and nodes would be less exact.

In estimating the light of the comet that of Dec. 1 is regarded as unity, and if the computers are right, at nearest approach, during the last of April and the first of May the comet will be a brilliant object, more than four hundred times as bright as it appeared at the time of discovery. It will then be circumpolar and hence the light of the *Moon* will be less troublesome.

During the month of April it has moved from between the small stars 12 and 14 of *Andromeda* to θ and ρ in a path curved slightly to the north; on the 22nd it was a little to the south and west of β *Andromedæ*, thence it crossed the corner of *Pisces* and the *Triangle*, and on the 26th it will be northeast of α *Arietis*, the 27th southeast of ν; the 28th south by west of δ, and on the last day of April to the south and west of λ *Tauri*. For the month of May its course will be still to the south and east; on the third, it passes a little east of *Rigel* of *Orion*; on the 6th southeast of *Sirius;* on the 10th it passes very near ε *Canis Majoris*, a second magnitude star, and so on, somewhat rapidly in south declination and beyond the reach of northern observers. Its most noticeable features will be its great changes in brightness between April 20 and May 5, and its rapid motion among the stars. On account of this last named fact it will afford a neat exercise for the amateur computer and observer to take naked eye observations of the comet about the time above mentioned, and attempt therefrom to compute the parabolic elements of its orbit.

The second comet was discovered by E. E. BARNARD, Nashville, Tennessee, Dec. 3, 1885. When first seen, it was exceedingly faint, with a small star-like nucleus in the preceding part of the nebulosity. Its motion then was nearly west, and on the same night, it was seen to pass almost centrally over a small

star, which shone through the nebulosity without probably any diminution of luster. Its position was near the western boundary of the constellation of *Orion*, and nearly five degrees north declination.

The elements of the orbit of this comet were computed by CHANDLER and WENDELL, HEPPERGER, KRUEGER, H. OPPENHEIM and others. Those by Dr. HEPPERGER are given below:

$$\left.\begin{array}{rl} T = & 1886\ \text{May}\ 3.3179\ \text{Berlin M. T.} \\ \omega = & 119^\circ\ 37'\ 41.''1 \\ \Omega = & 68\ \ 19\ \ 34.\ 9 \\ i = & 84\ \ 23\ \ 49.\ 9 \end{array}\right\} 1886.0$$

$$\log.\ q = 9.680413$$

Dr. HEPPERGER also computed from observations made Dec. 5, 10 and 15, elliptical elements for this comet, giving for the logarithms of a and e, respectively, 1.336444 and 9.990626, the remaining elements coming out substantially as those above given. The light of BARNARD'S comet, Dec. 5 is taken as unity. It will increase rapidly during the month of April and May 15, it will be brightest, appearing two hundred and sixty-five times as brilliant as it was on the second day after discovery.

During the month of April this comet has made a comparatively short path, moving pretty nearly northwest from α of the *Triangle* into the constellation of *Andromeda*, and on the 30th of April it will be between the stars γ and τ by Dr. OPPENHEIM'S ephemeris, which thus far follows the path closely. About this time the comet will change its course from north to south, and on the 10th of May it will be north and west of β in the *Triangle* and its motion thereafter will be rapid to the southeast.

The same may be said regarding the uncertainty of the elements of the orbit of comet Barnard as was said of Fabry and for the same reasons. E. WEISS in the *Astronomische Nachrichten* has claimed that these two comets will be conspicuous objects at the same time, and that about May 1 they will be quite near each other. It is also said that Comet Fabry passes its line of nodes May 8, which line the *Earth* passes April 27, and that the comet crosses the ecliptic April 25. It is therefore *possible* that the comet may be projected on the *Sun's* disc April

26 or 27. For reasons already given respecting the uncertainty of the position of the line of nodes there is only the merest *possibility* of such a transit, nor is it probable that persons in considerable north latitude will be favored in seeing these comets at their best because of unfavorable altitudes except in early morning hours during a few days.

The Comet Fabry was visible to the naked eye certainly as early as April 8. Mr. BARNARD, of Nashville, saw it on that day. He reports that "it presented a beautiful sight in the telescope, the head and tail being clearly defined. The nucleus was bright and star-like and slightly yellowish. The tail was long, narrow and very gradually brighter along the axis.

THE PRINCIPAL COMET METEOR STREAMS.

S. J. CORRIGAN, NAUTICAL OFFICE, WASHINGTON.

For The Messenger.

A computation of the elements of the orbits of four prominent meteoric comet streams, viz: the *Lyrids*, *Perseids*, *Leonids* and *Andromedes*, observations of which were given by Mr. DENNING in the April MESSENGER, discloses the following facts relative thereto. The elements have been derived from the *true* radiants according to the method given by me in the April number, and were also computed from the *apparent* radiants by the method published in the February MESSENGER. The eccentricity of each meteoric orbit was assumed to be the same as that of the associated comet, and the proper modifications were therefore introduced in the computation, but, since the eccentricities are nearly unity, these modifications do not cause the elements to differ materially from what they would be if the orbit were exactly a parabola. The greatest difference is in the case of the *Andromedes* or BIELA meteors, the eccentricity of BIELA's comet being considerably less than unity. I have also computed the position of the *apparent* comet radiants from the elliptic elements of the cometary orbits, and they agree very

closely with the positions of the meteoric radiants observed by Mr. DENNING on the dates of maximum.

In the following tabulation the dates of observation and the *apparent* positions, in right ascension and declination, of the radiants of the meteors and also of their associated comets, as observed, are given first. Then follow the *true* positions of the radiants as obtained by computation and then the elements and the velocities of the meteors and comets relative to the *Earth*. All are referred to the mean equinox of 1885.0

Lyrids.	April 18	April 19	April 20	Comet(1)1861.
	R. A. Dec.	R. A. Dec.	R. A. Dec.	R. A. Dec.
Pos. of app. radiant	260°.0+33°.5	267.°0+33.°0	274.°0+33.°5	270.°9+33°.5
" " true "	210 .5+55 .7	222. 9+58. 1	233. 3+61. 0	227. 6+59 .8
Long. of perihelion	255 42	248 54	240 34	243 42
" " node	29 05	30 04	31 03	30 16
Inclination	71 21	77 29	81 29	79 46
Perihelion distance	0.8478	0.8944	0.9402	0.9270
Motion	Direct	Direct	Direct	Direct
Velocity per second relative to Earth	28 miles	29 miles	30 miles	30 miles

The above elements suffice to show the close relationship of the *Lyrids* to comet (1) 1861. The elements of that portion of the stream which appears between April 19 and 20 to correspond very closely to the cometary elements, the meteor and comet radiants being within one degree of each other. The meteors of April 18 show a considerable deviation, the possible cause of which will be suggested farther on.

Perseids	July 26	Aug. 10	Aug. 19	Comet (III) 1862
	R. A. Dec.	R. A. Dec.	R. A. Dec.	R. A. Dec.
Pos. of app. radiant	27°.0+55°.0	45°.0+57.°0	68°.0+57°.0	43°.8+57.°2
" " true "	359 .1+81 .3	35 .2+83. 8	114 .2+78°.5	30 .2+83. 8
Long. of perihelion	333 41	346 03	371 35	345 00
" " node	124 04	138 26	147 05	137 46
Inclination	70 04	65 49	62 53	66 26
Perihelion distance	0.9491	0.9555	0.8664	0.9626
Motion	Retrograde	Retrograde	Retrograde	Retrograde
Velocity per second relative to Earth	36 miles	37 miles	37 miles	37 miles

From the above we see that the radiant of the meteors of August 10, the date of maximum is only about one half a degree distant from the cometary radiant, and the elements show a very good agreement with those of the comet.

The radiant of July 26 is about four degrees and that of August 19 about nine degrees from the cometary radiant. The difference between the true radiants is much less than that between the apparent.

Leonids	Nov. 13	Nov. 14	Nov. 16	Comet(I) 1866
	R. A. Dec.	R. A. Dec.	R. A. Dec.	R. A. Dec.
Pos. of app. radiant	148°.0 +23°.0	149°.0 +21.°0	150°.0 +22°.0	150°.4 +22°.8
" " true "	150 .8 +28 .9	151 .5 +26. 3	151 .8 +28 .5	153 .9 +29 .4
Long. of perihelion	54 08	55 33	52 18	60 45
" " node	231 50	232 49	234 50	231 42
Inclination	15 43	13 39	15 49	17 18
Perhelion distance	0.9884	0.9882	0.9876	0.9766
Motion	Retrograde	Retrograde	Retrograde	Retrograde
Velocity per second relative to Earth	44 miles	44 miles	44 miles	44 miles

The radiant of the *Leonids* lies within about two degrees from the cometary radiant, and the elements, while differing slightly, yet agree sufficiently closely to demonstrate the relationship.

Andromedes	November 27	Biela's Comet
	R. A. Dec.	R. A. Dec.
Position of app. radiant	23°.7 +44°.3	24°.0 +43°.2
" " true "	352 .0 + 9 .3	349 .9 + 7 .7
Longitude of perihelion	108 16	109 40
" " node	245 57	246 29
Inclination	13 08	12 33
Perihelion distance	0.8578	0.8606
Motion	Direct	Direct
Velocity per second relative to Earth	12 miles	12 miles

The agreement between the radiants and elements of the *Andromedes* and of the Biela comet is closer than that between any of the other three showers here discussed.

Having before us the above facts derived from observation and computation, we are led to the conclusion that the meteors

of each stream do not move in perfectly parallel lines, because, if they did, the *true* radiant would have the same position at all times. The deviations are within reasonable limits, and are probably caused, mainly, by the perturbing force of the *Earth*.

The members of the original streams may have moved in parallel lines, but passing so close to the *Earth*, the perturbations due to that body, must have thrown them into slightly different orbits, and in the course of many revolutions of the meteors, this effect would be very marked.

By perturbation the position of the radiant, and therefore the elements derived thereform would be changed.

Another possible cause of the deviation is suggested by the very great linear velocity of many of the streams. For example, the *Leonids* move relatively to the *Earth* at the rate of forty-four miles per second. Would it be at all surprising if these bodies, most of them probably of very small mass, should upon striking the denser portion of the atmosphere with this great velocity, be deflected and indicate, by their altered course, a radiant slightly different from that which they would otherwise give?

It would seem that perturbation (mainly by the *Earth*), and the deflection above referred to, would be *entirely* sufficient to account for all the differences, which evidently exist, between the radiants and also the elements, and that the relationship which these streams seem to bear to the associated comets, is a real one.

I would also propound the following queries: Is there any good reason why we should consider as moving in orbits where eccentricities are nearly unity, only those meteors whose orbital elements show them to be connected with known comets? May not all meteors, as distinct aggregations of matter, have an origin much the same as that of the comets, so that like the latter they move around the *Sun* in very eccentric orbits? A collection and discussion of all observed radiants would probably give the answer.

April 17, 1886.

A PRACTICAL METHOD OF WORKING ROCK SALT SURFACES FOR OPTICAL PURPOSES.*

JNO. A. BRASHEAR, PITTSBURG.

Two years or more since Prof. LANGLEY asked me to undertake the work of polishing the rock salt trains so frequently called into use in his well-known researches in obscure heat rays. These surfaces, under the very best conditions, are ephemeral in their character, owing to the deliquescent nature of the material, and in order to get the best results from them, frequent repolishing and refiguring are absolutely necessary. I have been informed that the French opticians polish all rock salt surfaces upon broadcloth; and, indeed, almost all surfaces I have tested show them to have been finished upon some yielding material, as the edges are almost always rounded, or as I would call it, over corrected. This is fatal to good results in any optical surface. Mr. GEORGE CLARK of ALVAN CLARK & SONS polished a prism for Prof. LANGLEY which turned out to be beautiful in polish and figure. His method was to use a pitch polisher with "diamantine" (a fine variety of Vienna lime) as the polishing material. A strong brine was used instead of water, in the ordinary way. Mr. CLARK informed me that the one great difficulty he met with was to wipe the prism surfaces *after the polishing was completed*, he using the arm or palm of the hand, in preference to anything else. On a few occasions I have succeeded in this way, but where success may be had once, failure may result twenty times, for if any moisture is left on the surface of the prism or lens, even for a moment of time, it is ruined.

Happily I have no trouble in this respect now, and as my method is easily carried out by any physicist who desires to work with rock salt surfaces, it gives me pleasure to explain it. For polishing a prism I make an ordinary pitch bed of about

* Read before the American Association for the Advancement of Science, Ann Arbor Meeting, August, 1885.

two and one-half or three times the area of the surface of the prism to be polished. While the pitch is still warm I press upon it any approximately flat surface, such as a piece of ordinary plate glass. The pitch bed is then cooled by a stream of water, and conical holes are then drilled in the pitch with on ordinary counter sink bit, say ¼ in. diameter, and at intervals of half an inch over the entire surface. This is done to relieve the atmospheric pressure in the final work. The upper surface of the pitch is now very slightly warmed and a true plane surface (usually a glass one, prepared by grinding and polishing *three* surfaces in the ordinary way), previously wetted is pressed upon it until the pitch surface becomes an approximately true plane itself. Fortunately moderately hard pitch retains its figure quite persistently through short periods and small changes of temperature, and it always pays to spend a little time in the preparation of the pitch bed.

The polisher being now ready, a very small quantity of rouge and water is taken upon a fine sponge and equally distributed over its surface. The previously ground and fined salt surface (this work is done the same as in glass working) is now placed upon the polisher and motion *instantly* set up in diametral strokes. I usually walk around the polisher while working a surface. It is well to note that the motion *must be constant*, for a moment's rest is fatal to good results, for the reason that the surface is quickly eaten away, and irregularly so, owing to the holes that are in the pitch bed. Now comes the most important part of this method. After a few minutes' work the moisture will begin to evaporate quite rapidly. No new application of water is to be made, but a careful watch must be kept upon the pitch bed and as the last vestige of moisture disappears the prism is to be slipped off the polisher in a perfectly horizontal direction, and if the work has been well done, a clean, bright and *dry* surface is the result. The surface is now tested by the well known method of interference from a perfect glass test plate.

XUM

If an error of concavity presents itself the process of polishing is gone over again, using *short* diametral strokes. If the error is one of convexity, the polishing strokes are to be made along the chords, extending over the edge of the polisher. The essential feature of this method is the fact that the surface is *wiped dry* in the final strokes, thus getting rid of the one great difficulty of pitch polishing, a method undoubtedly far superior to that of polishing on broadcloth. If in the final strokes the surface is not quite cleaned I usually breathe upon the pitch bed, and thus by condensation place enough moisture upon it to give a few more strokes, finishing just the same as before. In ten minutes I have polished prisms of rock salt in this manner that have not only shown the D line double, but Prof. LANGLEY has informed me that his assistant, Mr. KEELER (J. E.), has seen the nickel line clearly between the D lines, as well as every line that can be seen by the use of a good flint glass prism, although the dispersion is not so great. This speaks for the superiority of the surfaces over those polished on broadcloth.

In polishing prisms I prefer to work them on top of the polisher as they can be easily held, but as it is difficult to hold lenses or planes in this way, without injuring the surfaces, I usually support them in a block of soft wood, turned so as to touch only at their edges, and work the polisher over them. Though it takes considerable practice to succeed at first, the results are so good, that it well repays the few hours' work it requires to master the few difficulties it presents.

NEW MINOR PLANETS.—Dr. PALISA at Vienna discovered a new minor planet on March 31.5214, Gr. M. T. R. A. $14^h\ 0^m\ 34.6^s$. Dec. $-1°\ 17'\ 17''$. Daily motion in R. A. -48^s, in Dec. N. $1'$. 13th magnitude. Others on April 2.4905, Gr. M. T. R. A. $14^h\ 0^m\ 4.7^s$. Dec. $-5°\ 31'\ 24''$. Daily motion in R. A. -48^s, in Dec. 0. 13th magnitude. And April 3.4473, Gr. M. T. R. A. $12^h\ 24^m\ 44.9^s$. Dec. $-0°\ 40'\ 11''$. Daily motion in R. A. -40^s in Dec. N. $9'$. 12th magnitude. Also another on April 5.5532, Gr. M. T. R. A. $14^h\ 1^m\ 53.3^s$. Dec. $-1°\ 29'\ 5''$. Daily motion in R. A. -44^s, in Dec. N. $3'$. 13th magnitude.

EDITORIAL NOTES.

There are still in hand a few more copies of GALLE's Catalogue of Comets from 1860 to 1884 as translated from the German, by W. C. WINLOCK. Single copies fifty cents.

A scholarly mathematican and computer highly appreciates the articles of Mr. S. J. CORRIGAN on the computation of meteor orbits. A prominent English astronomer also gives him a handsome compliment.

SMALL EQUATORIAL FOR LICK OBSERVATORY.—Messrs. WARNER and SWASEY, Cleveland, Ohio, have recently shipped to the Lick Observatory a 6-inch equatorial provided with all their latest improvements, also one of their chronographs of new design.

COMET-METEOR RADIANTS.—Below will be found the radiant points and distances of the five new comets of last year. The present list is a continuation of my previous one given in the SIDEREAL MESSENGER, 1885 p. 153. The first column contains the current number; the second gives the designation of the comet by the recent method in the order of perihelion passage of the year; the third, the discover; the fourth, the day of the *Earth's* passage through plane of comet's orbit; the fifth designates the nearest node; the sixth, the distance of this node from the *Earth's* orbit in the order $R - r$, the *Earth's* distance from the *Sun* being taken as unity, the seventh and last column gives the radiant for the day in question.

No.	Designation of Comet.	Discoverer.	Earth's Passage.	Designation of node.	Earth's dist. from node.	Com.-met. rad. R. A.	Com.-met. rad. Dec.
1	1885 II	Barnard	June 23	Descending	−1.51	325°.8	+55°.0
2	1885 III	Brooks	April 14	Ascending	+0.12	184 .5	−73 .9
3	1885 V	Brooks	June 13	"	−0.18	201 .4	−87 .0
4	1886	Fabry	April 26	Descending	+0.11	322 .6	+36 .9
5	1886	Barnard	May 29	"	+0.36	350 .8	+49 .0

O. C. WENDELL.

HARVARD COLLEGE OBSERVATORY, 1886, April 17.

LARGE TELESCOPE FOR SMITH COLLEGE.—From private letter we learn that Smith College, at Northampton, Mass., has given the order for an equatorial of eleven inches aperture, and a steel dome of twenty-one feet in diameter to Messrs. WARNER & SWASEY, of Cleveland, Ohio. It is expected that the Observatory will be completed and the telescope in place before the close of the present school year.

SKETCHING THE FABRY AND BARNARD COMETS.—One or two suggestions for those desiring to make drawings of the tails of comets Barnard and Fabry may perhaps be of service. For those who have access to a catalogue of naked eye stars it will be well to plot the positions of all the stars in the neighborhood of the comet's tail before making the observation, and then drawing the outline of the tail among these stars. By this means a more accurate drawing can be made, and the original observation published without a second drawing and consequent touching up. A good way to prepare these maps is to use common computing paper ruled into squares of about one-fifth inch. By making one of these squares equal 30′ a very good sized drawing will result. If quite a liberal distance is plotted on each side of the tail the same map may be transfered to a number of sheets by pricking through the stars into sheets placed below the map. A field or opera glass will be found of great help in making detailed drawings, stars as faint as 7.5 magnitude may then be plotted. The following catalogues are recommended for getting places of the stars: Uranometria Nova, Uranometrie Generale, found in the Annales de l'Observatoire Royal de Bruxelles, Tome I, HEIS'S Catalogue or Uranometria Argentina.

Observations for magnitude of the various parts of the tail may be made when dawn is appearing (not so well in the evening twilight) by observing what parts disappear simultaneously with a neighboring star. The time of the disappearance should be noted, and care taken to have the star of about the same al-

titude as the observed part of the tail. In the same way an approximate determination of the brightness of the nucleus may be made. The following ephemerides give the approximate position and time of rising or setting during the most favorable time for observation:

BARNARD.

Date	R. A.	Dec.	Rises
May 3	$1^h\ 38^m$	$+40^\circ\ 24'$	$1^h\ 50^m$ A. M.
7	1 43	39 09	1 50 " "
11	1 53	36 12	2 00 " "
15	2 11	30 50	2 40 " "
19	2 40	21 53	3 30 " "

FABRY.

			Sets
May 1	$4^h\ 13^m$	$+\ 3^\circ\ 33'$	$7^h\ 50^m$
3	5 1	$-\ 7\ 44$	
5	5 42	$-16\ 43$	7 50
7	6 16	$-23\ 6$	
9	6 43	$-27\ 31$	7 50

Those unable to provide maps of the above regions will be supplied by addressing Leander McCormick Observatory, University of Virginia. F. P. LEAVENWORTH.

NEW NEBULOUS STAR.—On March 3 I found with the 6-inch COOK equatorial a star of $9\frac{1}{2}$ or 10 magnitude, with a faint nebulosity surrounding it.

Its place from two ring micrometer comparisons with No. 1659 of GRANT'S Glasgow Catalogue is

$$\left.\begin{aligned} \alpha &= 6^h\ 40^m\ 58.0^s \\ \delta &= +1^\circ\ 26'\ 27'' \end{aligned}\right\} 1886.0$$

I strongly suspect that it is not a stellar point but an extremely small nebula with faint nebulosity surrounding. At best with the 6-inch it did not appear like any of the neighboring stars. A short distance ($4'$ or $5'$) preceding this and very slightly north is a faint double-star that I suspect is enveloped in nebulosity. The nebulous star has been seen on several different occasions and always appeared the same. E. E. BARNARD

VANDERBILT OBSERVATORY, April 13, 1886.

DARK TRANSITS OF JUPITER.—In answer to Mr. WILSON's interesting note about III in SIDEREAL MESSENGER for April p. 125, I would state that the satellite very frequently transits as a black spot. I have observed it thus on the following dates: August 2, 1879; December 30, 1880; February 12, 1883, when it appeared as a small very black spot, smaller than its shadow generally is. See SIDEREAL MESSENGER, March 1883, p. 31; May 9, 1885, small, round, black on north edge of equatorial band; see SIDEREAL MESSENGER, July 1885, p. 158. I have several other records of similar black transits of the satellites among my notes that I cannot at the moment find. There are now probably a sufficient number of recorded black transits of this moon to give data for the investigation of the cause of the phenomenon. I have several times witnessed black transits of the IV satellite. In 1880, I saw quite a number of brown transits of I, but I have never seen II transit otherwise than bright.

Red Spot.—I have observed this object several times this year; it seems to be clearly defined and not difficult of observation, and sustains identically the form of previous years. The southern part of the equatorial belt curve southward following red spot as it has frequently done in former years, and very noticably last year. Since my first observation of the red spot I have been struck with the remarkable fact that it exerts a repellant force against the equatorial belt, never permitting a closer approach to it than probably about one-half the width of red spot.

Peculiar dark spots at the equator.—I have several times lately noticed a feature that has become very striking on April 1. There are several spurs or projections from the inner edge of the southern part of equatorial band. Examining the planet on the above date with a power of about 90 on the 6-inch, I noticed what I took to be the shadow of one of the satellites, this at $11^h\ 25^m$ Nashville M. T. was central in transit at the equator, upon applying a power of 200 I found that which from its small size and blackness I had mistaken for a shadow, was

really one of the projections seen before, but how much darker. Following this some distance was a similar object, whilst on the northern edge of equatorial belt was a feebly luminous spot. At 12*h* 45*m* three of these dark projections were visible ranged along the inner edge of belt and *just* south of equator, I noticed that from the summit of each there extended in a following direction a dusky streak for a short distance and looking like smoke. I was strongly impressed with the resemblance to what might be called a silhouette view of three volcanic peaks ranged in a line and vomiting smoke which a stray wind was carrying eastward! I have always noticed a tendency of any projections from the inner sides of the great equatorial belt system to curve backwards as they approached the equator, as if there were a more rapid motion of the edges of the belt system than along the equator. E. E. BARNARD.

VANDERBILT OBSERVATORY, Nashville, Tenn., April 5, 1886.

WEATHER TELEGRAPHIC SIGNALS IN NORTH AMERICA.—The foregoing is the title of an interesting paper recently written in German by Professor J. HAGEN, College of the Sacred Heart, Prairie Du Chien, Wisconsin. The points discussed are—

1. The history of the weather service in North America.
2. The organization of the service.
   (1). Pertaining to observers.
   (2). Pertaining to stations.
3. Work of the service.
   (1). That done at stations.
   (2). That done at the central office.

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o CETI.—E. F. SAWYER, Cambridgeport, Mass., reports that the maximum of *o Ceti* occurred January 9, 1886. It was a faint one equalling a fifth magnitude. This is very unusual for its range of variation at different maxima is commonly between the fourth magnitude and the second. The *Gesellschaft* announced the maximum to come in January 7 for 1886. The mean period is about three hundred and thirty-three days.

POSITION ANGLES OF THE TAIL OF COMET FABRY.—The following are the measured position angles of the tail of FABRY's comet made with the 6-inch COOK refractor of this observatory:

Date	Nashville M.T.	Position angle	Remarks.
1886			
April 7	4h 17.m4	315°.75	3 obs., tail straight slender, well-defined,
" 12	4 6. 8	314 .70	4 obs., tail straight, broader than formerly, defined.
" 13	4 9. 1	318 .20	3 obs., tail straight, broader, not well

The comet on the above mornings has been an easy object to the naked eye, but not at all conspicuous. In the telescope the nucleus was bright and surrounded by a considerable glow. On the 13th the sky was poor, and the tail did not appear so bright. On each occasion, the axis of tail has been gradually brighter than its edges.

E. E. BARNARD.

VANDERBILT OBSERVATORY, Nashville, Tenn., April 12, 1886.

ELEMENTS OF COMET BARNARD:—The following elements are also by OPPENHEIM in A. N. No. 2714:

1886	R. A. h. m. s.	Dec. ° ′	Log. r.	Log. Δ.	Brightness.
May 2	38 8	+40 28.4	9.6796	9.9556	118
3	38 33	40 19.5		9.9401	
4	39 14	40 5.9	9.6804	9.9238	136
5	40 14	39 47.4		9.9069	
6	41 34	39 23.5	9.6858	9.8894	155
7	43 16	38 53.6		9.8711	
8	45 23	38 17.2	9.6955	9.8522	176
9	1 47 57	+37 33.8		9.8327	
10	1 50 59	+36 42.5	9.7087	9.8125	199
11	54 31	35 42.6		9.7917	
12	1 58 36	34 33.4	9.7248	9.7704	225
13	2 3 15	33 13.8		9.7487	
14	8 29	31 42.6	9.7429	9.7266	253
15	14 20	29 58.4		9.7042	
16	20 49	28 0.3	9.7624	9.6818	284
17	27 56	25 46.9		9.6594	
18	35 41	23 16.9	9.7828	9.6374	318
19	44 5	20 29.1		9.6164	
20	2 53 8	17 23.0	9.8035	9.5964	349
21	3 2 48	13 58.5		9.5781	
22	13 3	10 16.3	9.8242	9.5619	371
23	23 51	6 18.4		9.5485	
24	35 8	+ 2 7.9	9.8448	9.5383	377
25	46 52	− 4 10.8		9.5318	
26	3 58 59	− 6 32.5	9.8648	9.5291	359

ELEMENTS OF COMET FABRY.—The following elements are by OPPENHEIM in A. N. No. 2715:

1886.	R. A. h m s	Dec. ° ′	Log. r.	Log. Δ.	Brightness.
May 1	4 12 43	+ 3 33.4	9.9218	9.2984	457
2	4 37 42	− 2 16.8			
3	5 1 12	7 43.6	9.9351	9.3266	378
4	22 51	12 32.9			
5	5 42 31	16 42.6	9.9484	9.3810	277
6	6 0 11	20 11.9			
7	15 57	23 6.1	9.9617	9.4455	193
8	30 1	25 31.1			
9	42 32	27 30.8	9.9748	9.5100	135
10	6 53 42	29 10.5			
11	7 3 40	30 34.7	9.9877	9.5705	97
12	12 35	31 45.1			
13	20 37	32 45.5	0.0004	9.6260	70
14	27 52	33 37.1			
15	34 22	34 21.8	0.0130	9.6763	53
16	40 30	35 1.9			
17	46 0	35 35.2	0.0253	9.7220	40
18	51 3	36 5.4			
19	7 55 43	39 32.2	0.0373	9.7636	32
20	8 0 3	36 56.3			
21	4 5	37 18.1	0.0491	9.8017	25
22	7 51	37 38.0			
23	8 11 23	−37 56.1	0.0606	9.8367	20

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BOOK NOTICES.

A Popular History of Astronomy During the Nineteenth Century by AGNES M. CLERKE. Publishers, Messrs. ADAM and CHARLES BLACK, Edinburg, Scotland, 1885, 8vo, pp. 468.

This book is a genuine surprise because of its merit and its timely appearance, and because it was not written by a man;

for the years are few since the time that a woman either could or would have written a book on astronomy for popular reading in Europe or America, because the *savants* would have thought such an undertaking strangely unorthodox according to any scientific creed.

But ideas have changed somewhat since the time of CAROLINE HERSCHEL and MARIA MITCHEL (now of Vassar College Observatory) and the doors of Science open more easily and naturally to merit and skill, in any person, than they were wont to in earlier days.

To write a history of astronomy to follow such an author as GRANT, which shall clearly present its marvellous growth, in all the varied and intense specializations of work, in the nineteenth century, is indeed a task that few astronomers in the world would not hesitate to undertake.

In the midst of such difficulties Miss CLERKE has gathered the materials of this book and written it admirably. The theme is divided into two parts, the first treating of the progress of astronomy during the first half of the nineteenth century, and the second is a critical review of the recent progress of the science. Under the first head, the work of Sir WILLIAM HERSCHEL appears justly as the foundation of Sidereal Astronomy, on which the noted BESSEL begins to build exact astronomy in Germany. The skill of FRAUNHOFER is a useful adjunct at this time, and STRUVE'S double-star researches and Sir JOHN HERSCHEL'S explorations of the heavens are some of the characteristics of fifty years of progress in astronomy. Under the same head, are also presented the progress of knowledge regarding the *Sun*, planetary discoveries, comets, and instrumental advances.

About two-thirds of the book is devoted to the recent progress of astronomy, commencing with the foundation of astronomical physics, as seen in the discovery of the sun-spot period, magnetic disturbances and the elementary principles of spectrum analysis, the theory of the constitution of the *Sun*, solar photography, planetary influences. Then follows specialized study in recent solar eclipses, the spectroscopic study of the the *Sun*, the temperature of the *Sun*, its distance, planets and

satellites, theories of planetary revolution, recent oomets, stars and nebulæ, and methods of research.

From a careful reading of this book, it would seem from the form of expression, now and then chosen, that the authoress has not been a practical observer, and yet we can but admire the skill with which she freely and independently discusses impending problems of the science. We do not say that we fully endorse all positions taken as quite eatisfactory; for example, the claims regarding the discovery of *Neptune*, the theory of the solar corona, spectroscopic work, the personal equation, etc., but all these points and others in mind, are minor matters, which will neither seriously disturb or mislead any body. The fresh, apt and terse way, in which the good things of every page are said to overshadow the weak ones that they are scarcely noticeable.

We have read this book with delight, and in commending it to the readers of the MESSENGER we bespeak for it unusual favor in Americe.

A Catalogue of Suspected Variable Stars. With Notes and Observations. By J. E. GORE, M. R. I. A., F. R. A. S.

This catalogue of suspected variable stars was presented as a paper before the Royal Irish Academy in 1884, and reprinted from its proceedings. It contains 158 pages of closely printed matter with a frontispiece double-page plate showing the distribution of known and suspected variable stars, the known being red dots, while the suspected are black ones. The catalogue proper is arranged in six columns, on the page, first, the number of the star, second, its name; third and fourth, R. A. and Declination for 1880; fifth, supposed change of magnitude, and sixth, authority. Whole number of stars is 773, taken in order of right ascension. The notes accompanying are unusually full and apparently prepared with care and great labor.

The Catalogue is a valuable and needed contribution to this new branch of astronomy.

The new Minor Planets, recently discovered by DR. PALISA, are numbered respectively 254, 255, 256, 257.

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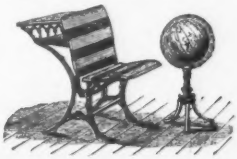

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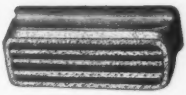

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Term Examinations, June 15 and 16, 1886.

Anniversary Exercises, June 14–17, 1886.

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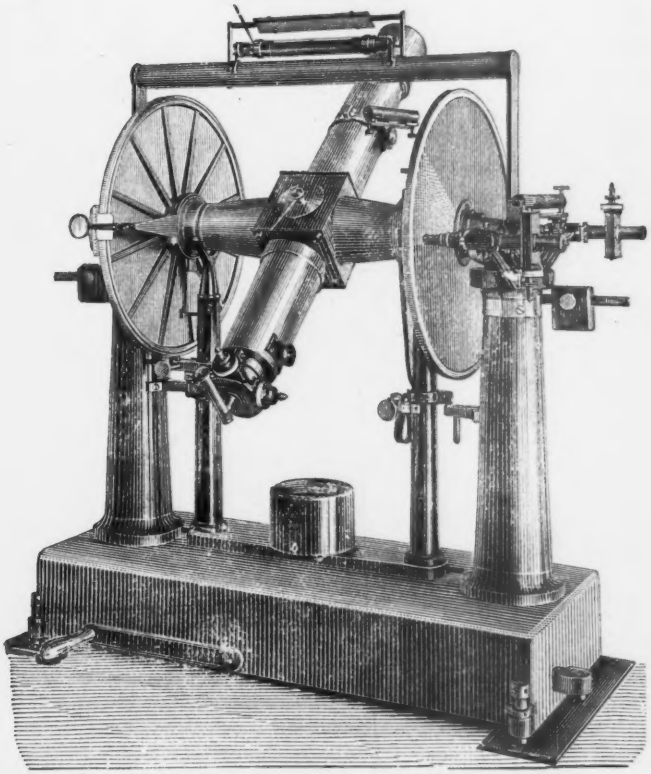

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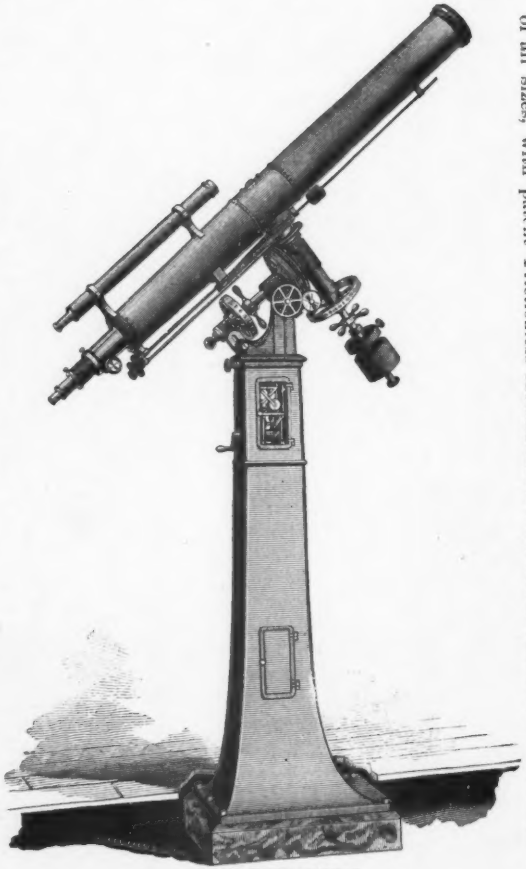

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